BAE SYSTEMS

ASPECTS OF USE OF CFD FOR UAV CONFIGURATION DESIGN

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UCAV DESIGN PROBLEM

BAE SYSTEMS

- Problem (for Aerodynamics) is as much due to novel planforms as Unmanned
- Novel planforms negate traditional Aerodynamic ground rules (sweep, span, AR etc)
- S&C is a significant challenge
- Requirement for rapid proto-typing for planform/basic layout studies and control surface optimisation
- Fast-response WT - small scale, stereo-lithography, PSP
- Fast-response CFD -Euler, High RE turb models RANS

TYPICAL EXAMPLE

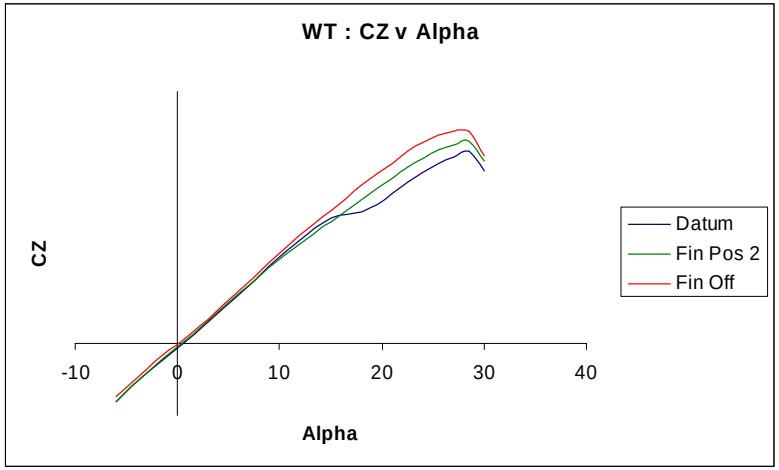
BAE SYSTEMS

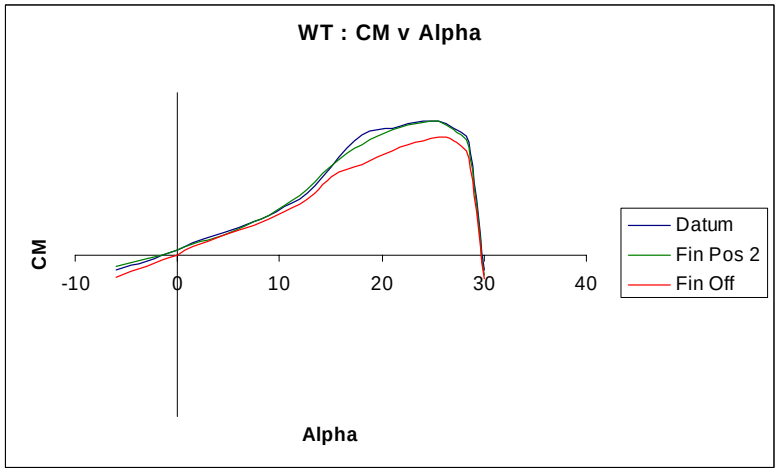
Investigation of Fin Position on a typical Novel Planform

- Establish credibility of CFD for prediction of general flow trends at low speed, high incidence for novel planforms
- Assist in interpretation of ‘small-scale’ wind tunnel testing

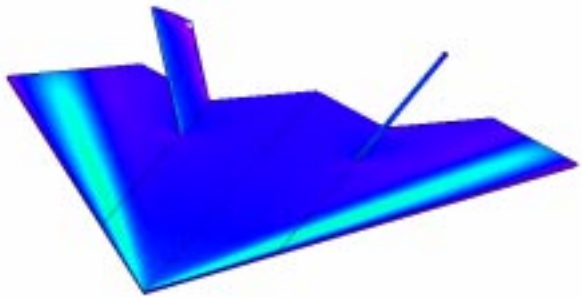
TYPICAL EXAMPLE

BAE SYSTEMS





Small Scale WT testing - Effect of fin position



Datum (flat-plate) model

NOTES ON CFD CALCULATIONS

BAE SYSTEMS

- 6-8million unstructured grid cells required for credible vortex capture from Euler, with particular emphasis on field resolution
- 2-3million ‘BAE Systems Autogrid’ cells required for equivalent capture from RANS
- kεRNG turbulence model (wall function) suitable
- Euler solution turnround 4hrs on 8 Origin processors, RANS 2 days

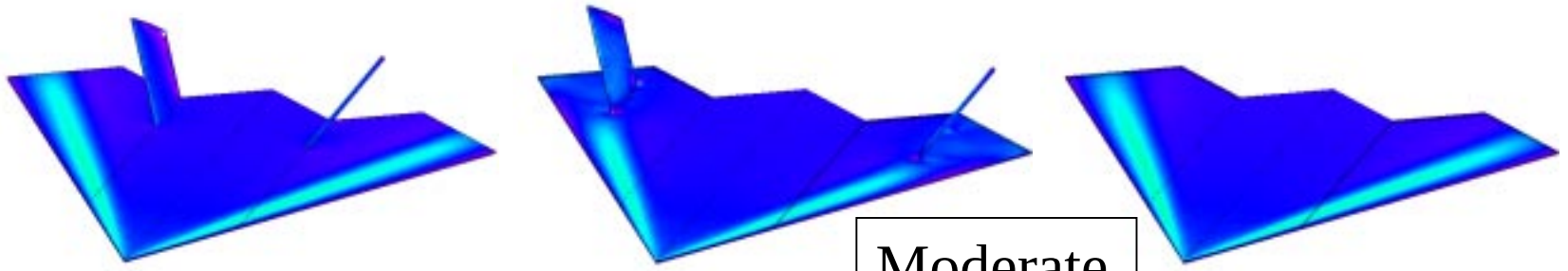
EFFECT OF FIN POSITION

BAE SYSTEMS

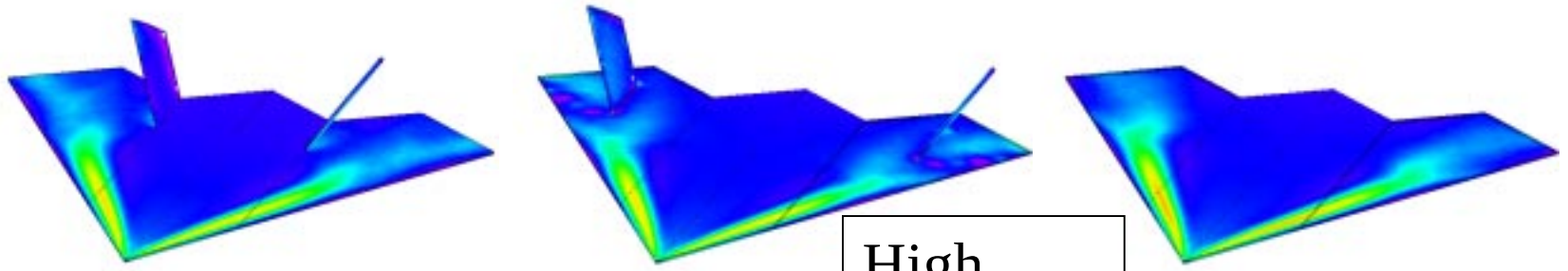
Datum

Fin Pos2

Fin Off



Moderate Incidence

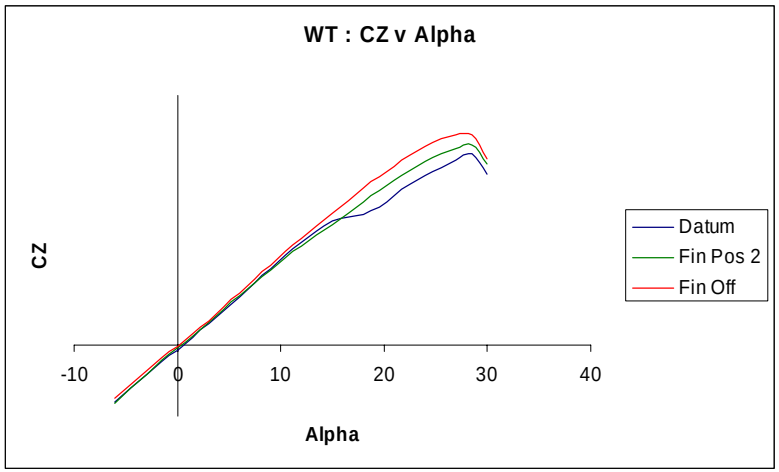


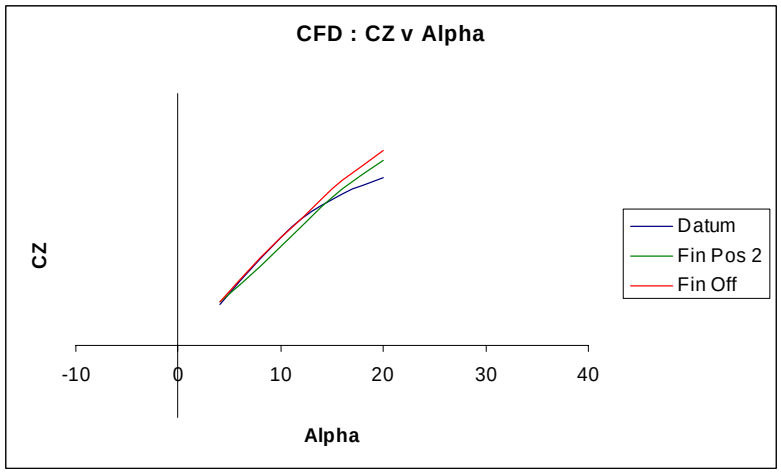
High Incidence

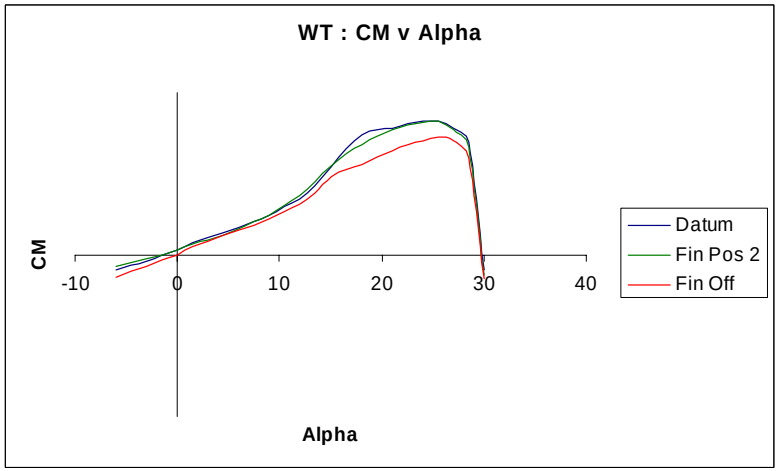
Flat Plate CFD Euler, local velocity contours

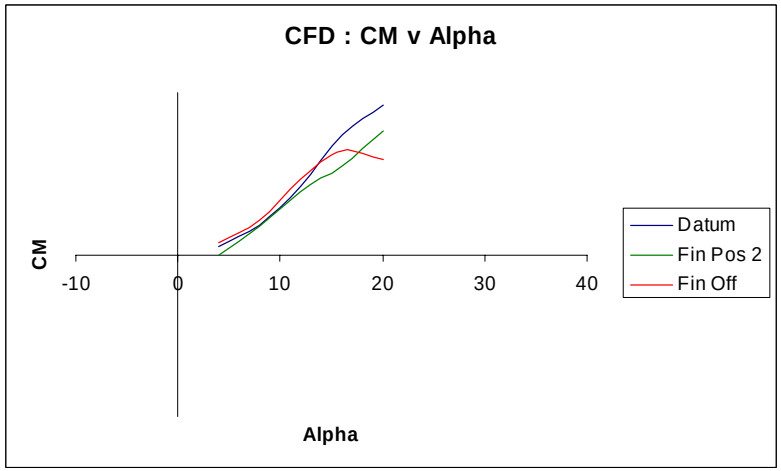
EFFECT OF FIN ON FORCES

BAE SYSTEMS





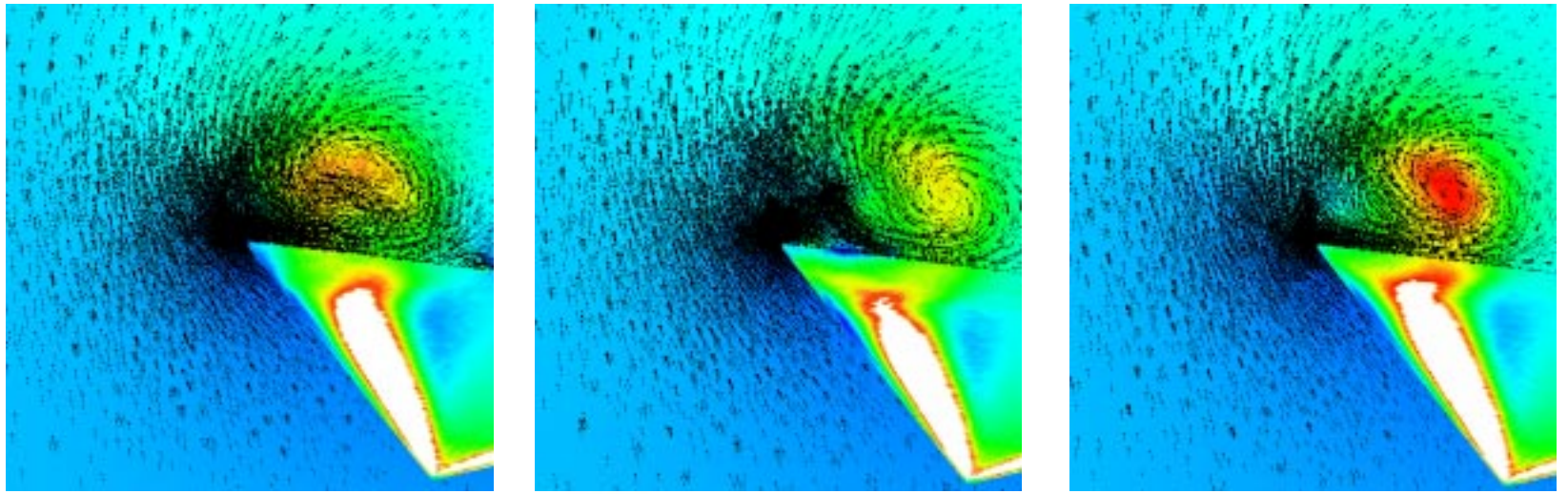


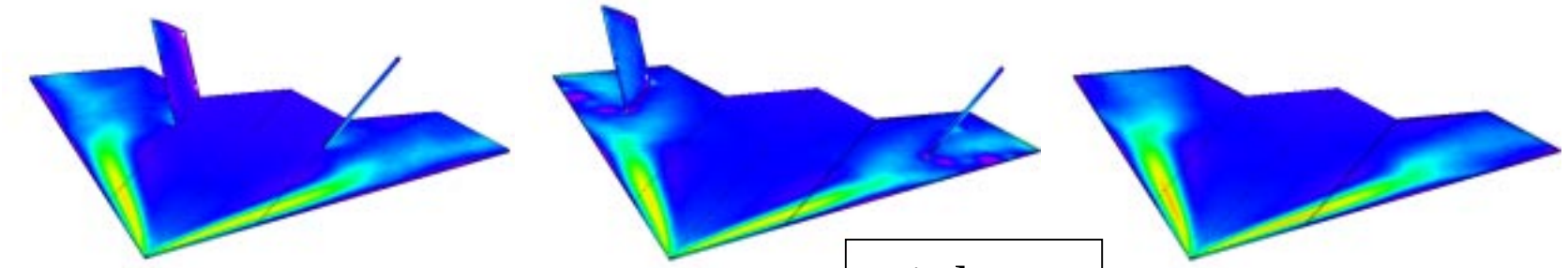


Flat Plate Wind Tunnel v CFD (Euler)

EFFECT OF FIN ON FLOWFIELD

BAE SYSTEMS





High Inc

Datum

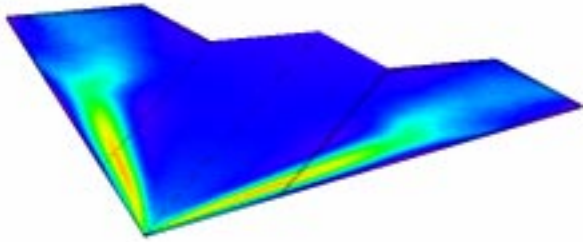
Fin Pos2

Fin Off

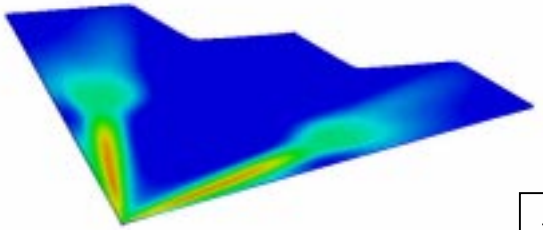
Flat Plate CFD Euler, velocity vectors, local vel contours

INVISCID v VISCOUS

BAE SYSTEMS



EULER



RANS

High Inc

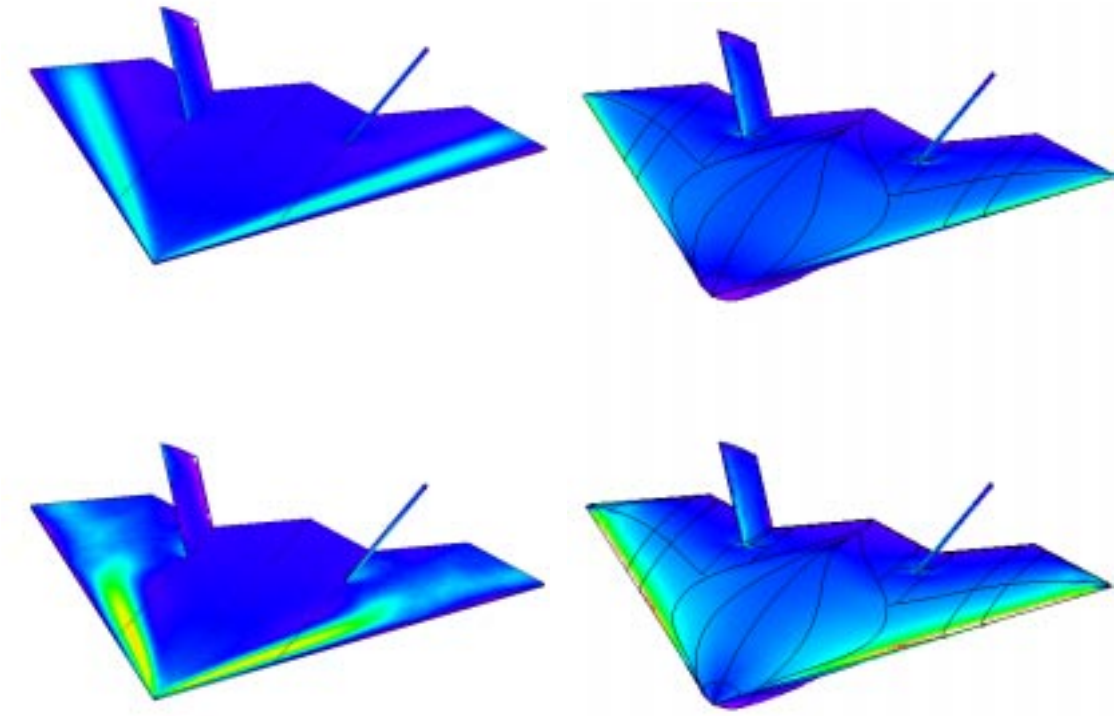
Flat Plate CFD Euler v RANS

EFFECT OF THICKNESS

BAE SYSTEMS

Flat Plate

10% t/c



Moderate Incidence

High Incidence

Flat Plate v Symmetric airfoil, CFD Euler, local vel contours

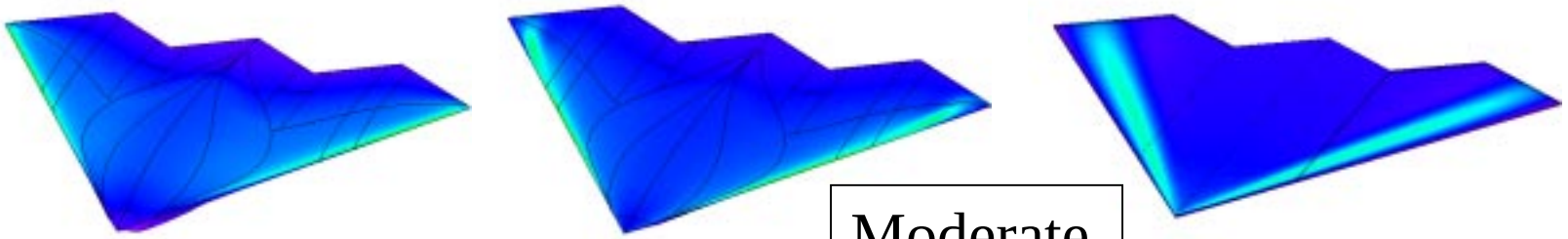
EFFECT OF THICKNESS (FIN OFF)

BAE SYSTEMS

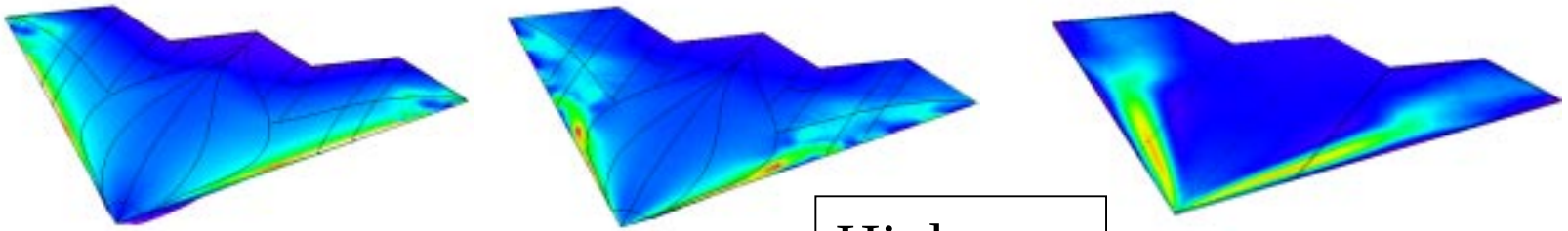
10% t/c

5% t/c

Flat Plate



Moderate incidence

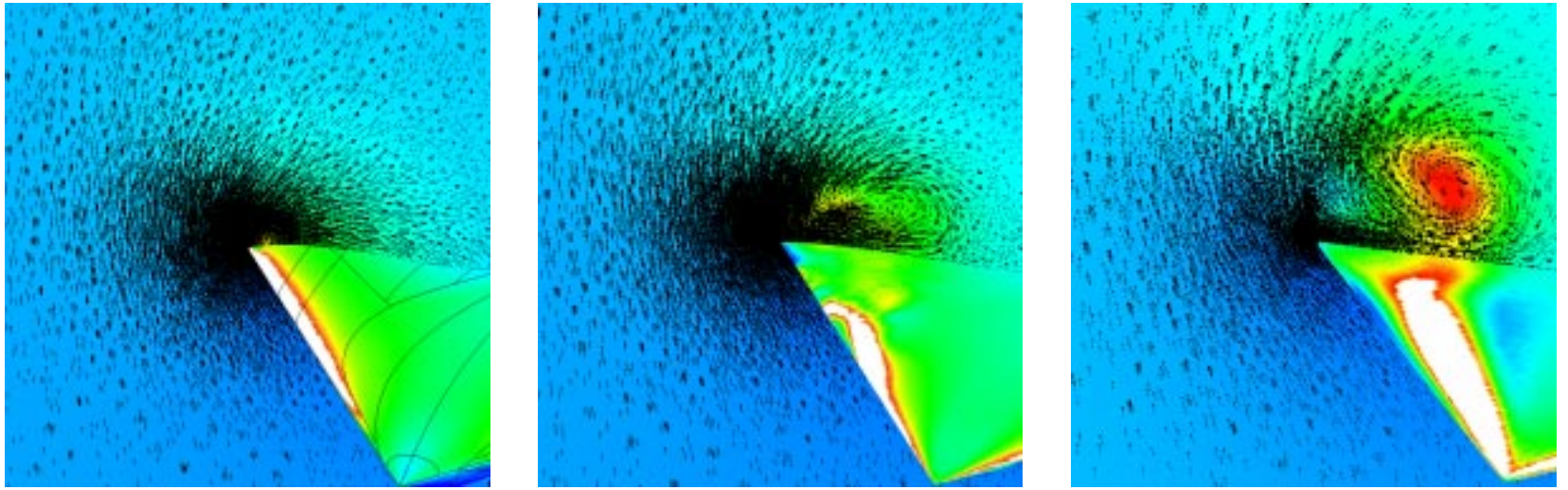


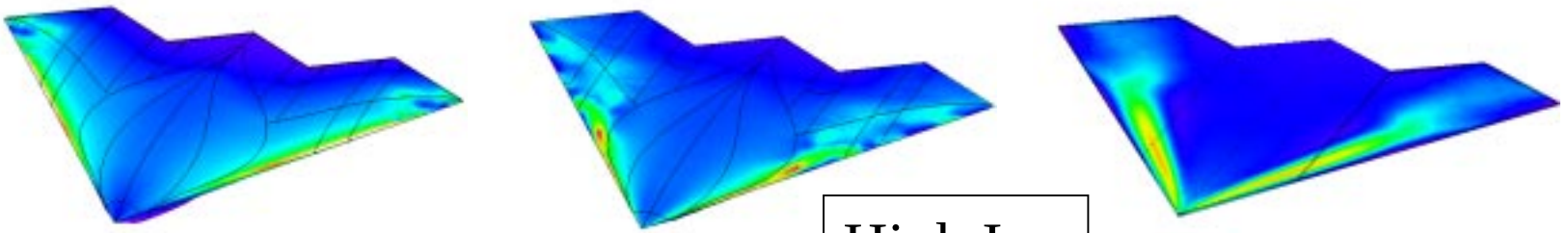
High Incidence

Flat Plate v Symmetric airfoil, CFD Euler, local vel contours

EFFECT OF T/C ON FLOWFIELD

BAE SYSTEMS





High Inc

10% t/c

5% t/c

Flat plate

CFD Euler, velocity vectors and local vel contours

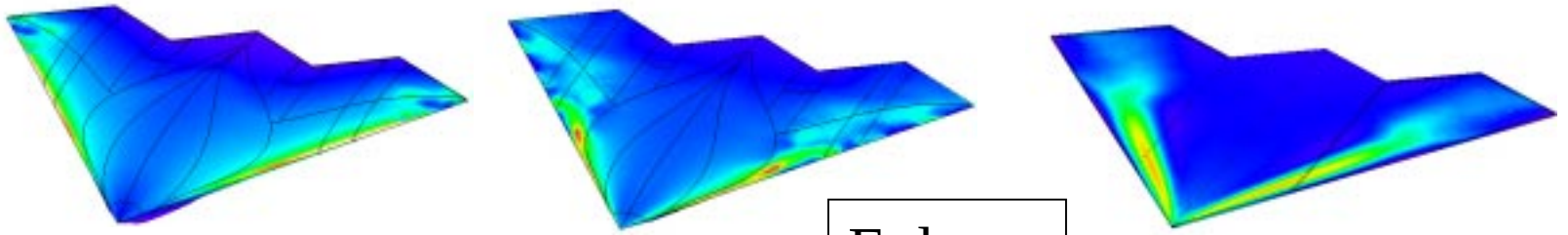
EFFECT OF T/C, EULER v RANS

BAE SYSTEMS

10% t/c

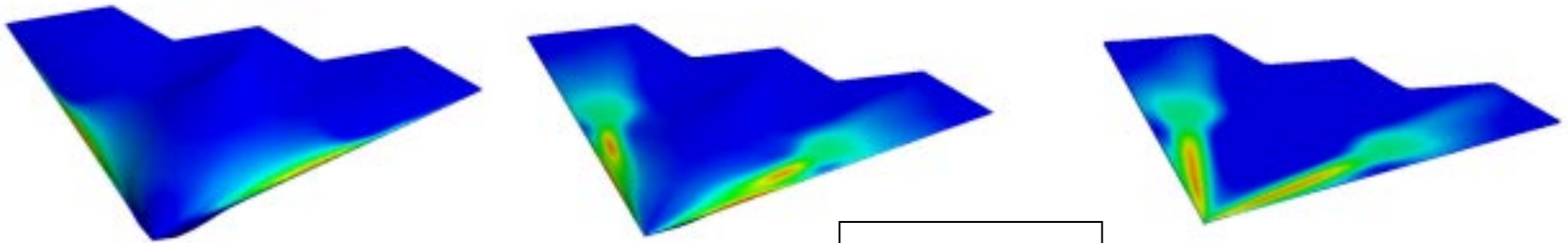
5% t/c

Flat Plate



Euler

High Inc



RANS

Flat Plate v Symmetric airfoil, Euler v RANS

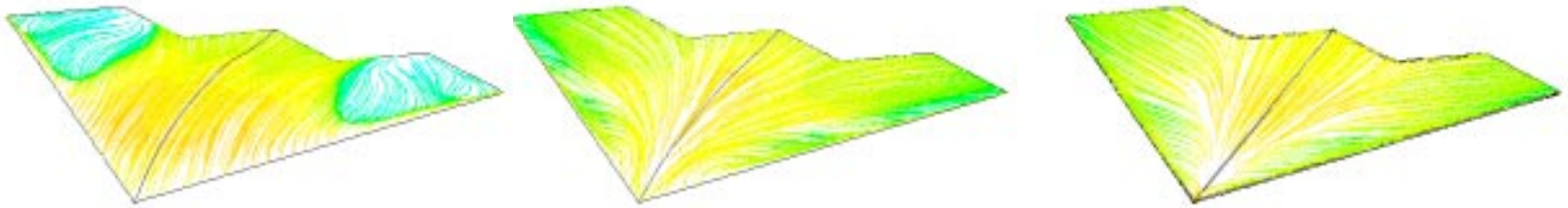
EFFECT OF THICKNESS

BAE SYSTEMS

10% t/c

5% t/c

Flat Plate



High Inc

RANS

CFD RANS, surface flow patterns

SUMMARY

BAE SYSTEMS

- Euler showing good prediction of flat plate
- Absolute values of pitching moment poor at high incidence, though engineering decisions can be made by interpretation
- RANS improves absolute predictions, though at too great an overhead in CPU time to be practical for design optimisation
- Difference in flow behaviour between thin and thick airfoils defines limit of applicability of flat plate wind tunnel models

FURTHER ASSESSMENT OF CFD

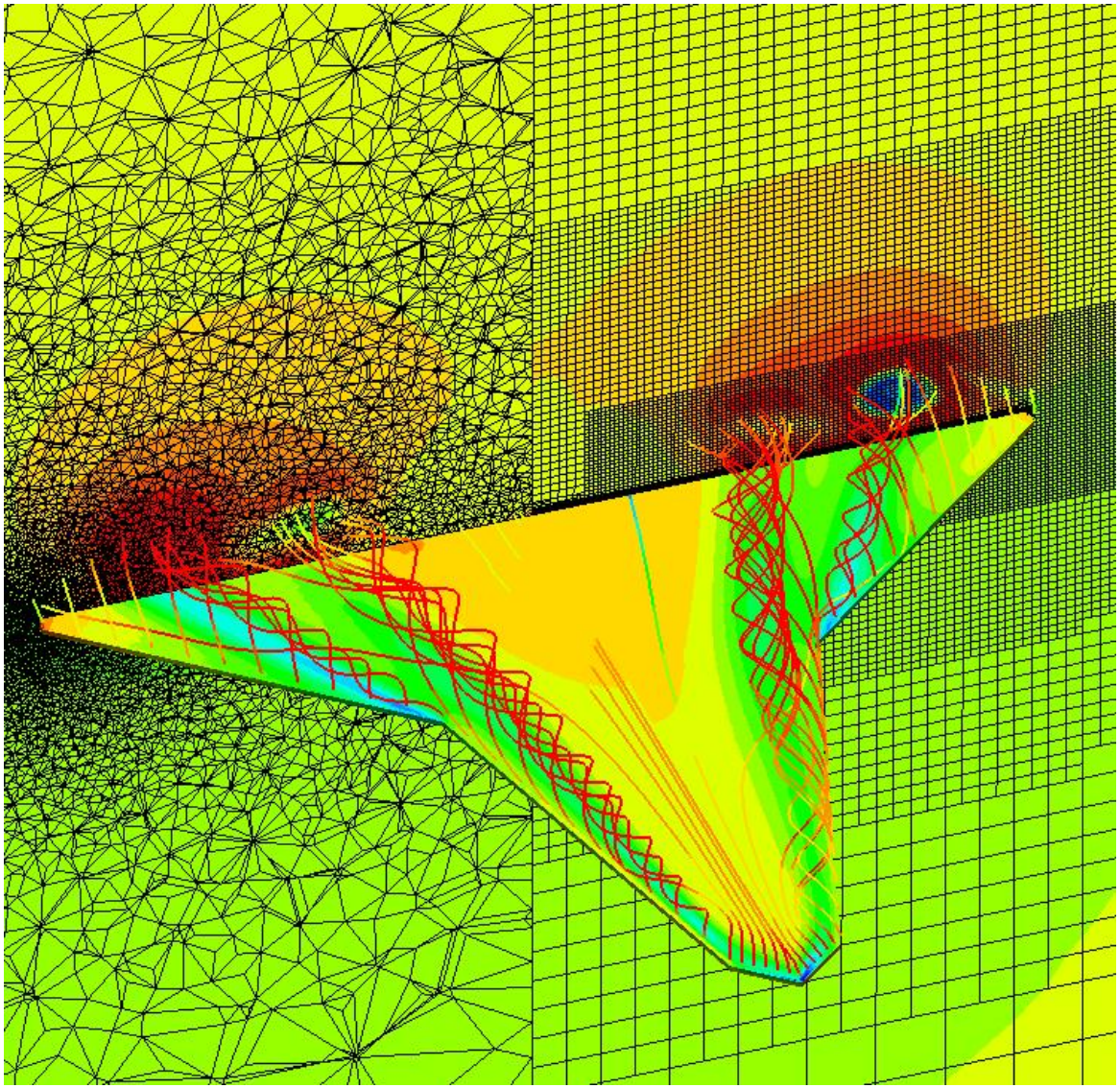
BAE SYSTEMS

- RANS assessed on BAE Systems Autogrid meshes for a vortical flow case and a mixed attached/separated flow case
- kg results poor for both cases in terms of comparison with limited WT data, RANS (kε RNG) and engineering judgement
- kε RNG results good for both cases

VORTICAL FLOW CASE

BAE SYSTEMS

EULER

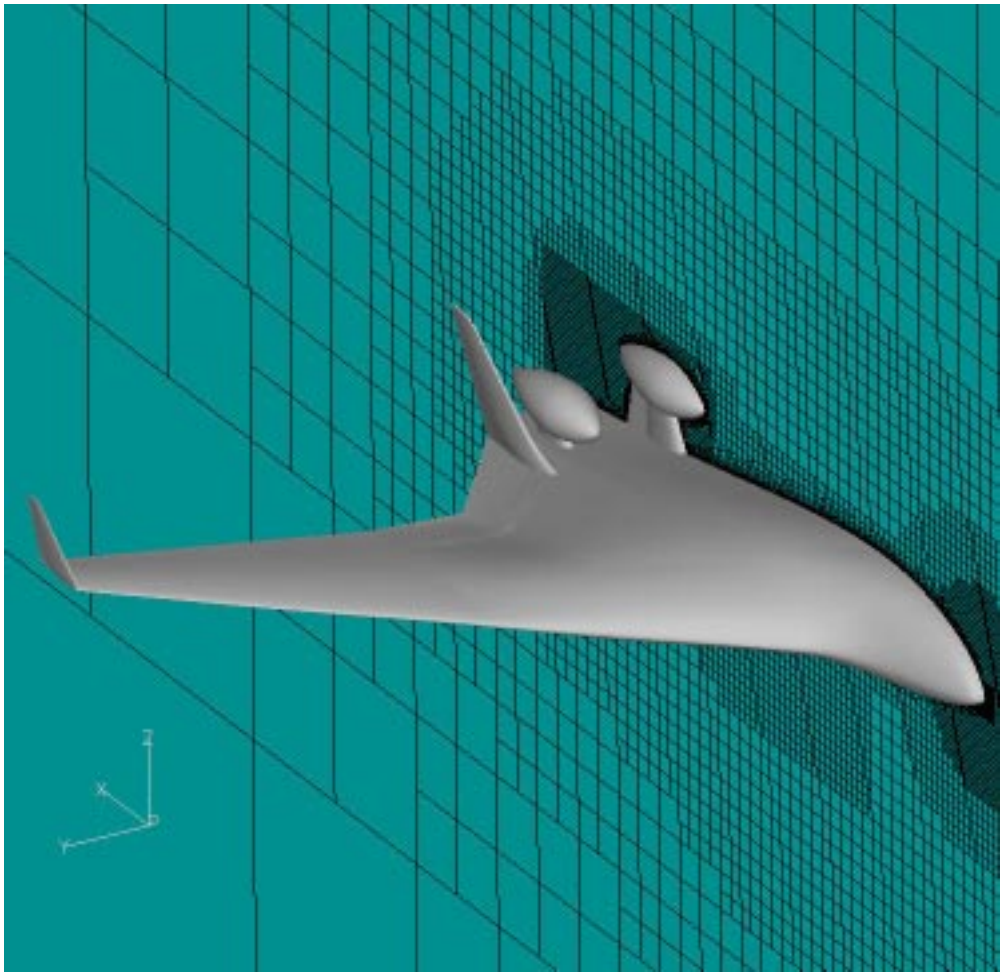


RANS

MIXED ATTACHED/SEPARATED FLOW CASE

BAE SYSTEMS

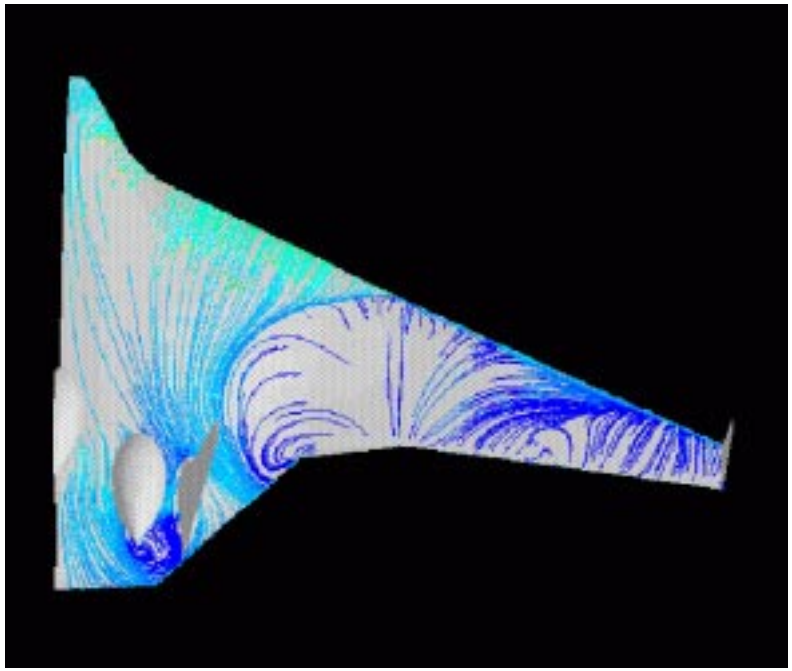
BWB



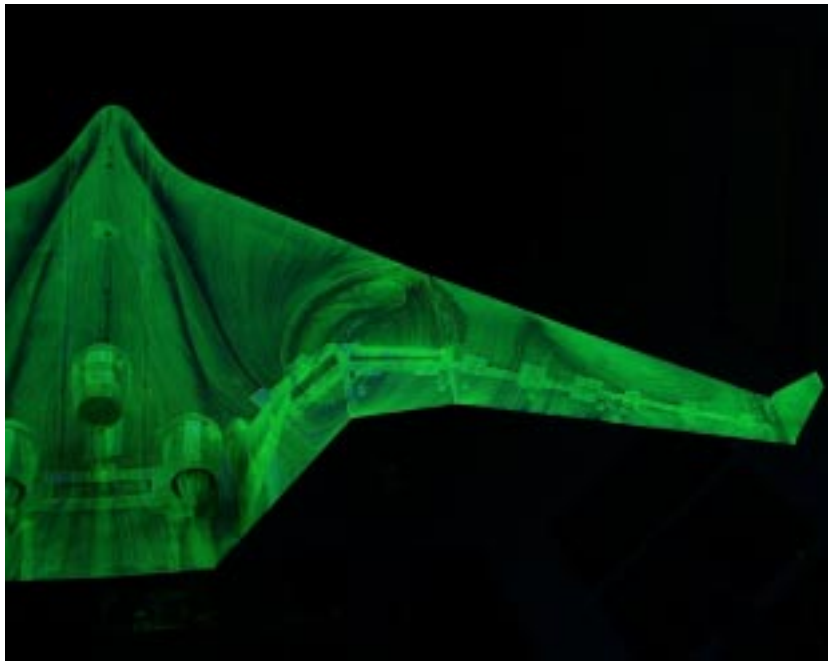
MIXED ATTACHED/SEPARATED FLOW CASE

BAE SYSTEMS

BWB High Incidence



RANS KERNG



WIND TUNNEL

CONCLUSIONS

BAE SYSTEMS

- Novel Planforms mean S+C Issues must be addressed early in the UCAV design cycle
- CFD and WT must work together here
- Requirement for rapid assessment
- Flat-plate and stereo-lith small-scale WT models, in conjunction with Euler and ‘reduced-accuracy’ RANS CFD can be applied here
- This approach requires engineering judgement and expertise to be fully effective